in an orderly arrangement and are considerably higher than the vegetative temperature line. In figure 3 the average length of the potential growth, or vegetative, period is compared with the average frostless period for the same belts that were used in the construction of figure 2. This shows graphically for the several belts the effect of killing frost in shortening the potential vegetative period in so far as plants that are susceptible to frost damage or destruction are concerned.

Charts VI and VII show, respectively, the average number of days by which the potential growing season is shortened in spring and in fall by frost. Chart VI indicates the average number of days in spring after the vegetative temperature period is reached until the average date of the last killing frost, while Chart VII shows the average number of days the first killing frost in fall occurs before the mean daily temperature falls below the vegetative value. It will be noted that the spring and fall charts correspond to a remarkable degree.

Chart VIII shows the total number of days that the average frostless season is shorter than the vegetative period. It indicates that the only locality in which the frostless season is longer than the vegetative period is comprised in a small area along the North Pacific coast. In most of Washington, portions of upper Michigan, and much of Minnesota, as well as along the North Atlantic seaboard, killing frost shortens the vegetative period by less than 20 days, but in much of the central portion of the country the difference in the two periods ranges from 40 to 60 days. From Virginia, Kentucky, Missouri, and Oklahoma southward this difference increases rapidly from 60 to more than 100 days in the northern portions of the Gulf States. Southward from the upper Mississippi Valley to southern Arkansas the difference increases from 20 to 100 days, or from less than one to more than 3 months.

Figure 5 shows for Cleveland, Ohio; Wichita, Kans.; and Atlanta, Ga., representing, respectively, regions of small, moderate, and large variations, the relation of the frostless season to the vegetative period for each of the 20 years from 1898 to 1917, inclusive. The dots represent the dates of the last killing frost in spring and the first in fall and the horizontal lines connecting the dots show the length of the frostless season for each year. The average dates on which the vegetative period is reached in spring and passed in fall are shown by the vertical dash lines.

This graph permits an interesting comparison between conditions existing in the vicinity of Cleveland and those near Atlanta. In the former locality the average frost dates agree closely with the vegetative temperature dates, and consequently the potential growing season is not materially shortened by the occurrence of frost. Protection of truck crops from frost in this locality, therefore, would be of less value in lengthening the growing season than farther south. In the vicinity of Atlanta, however, the vegetative period is much longer than the frostless period, and consequently hardy vegetation, such as winter grains and grasses, has a much longer growing season than has vegetation susceptible to frost damage. It follows that frost protection can be much more profitably practiced in northern Georgia than in northern Ohio. South of Atlanta, the mean daily temperatures remain above the vegetative value throughout the year, which makes an even greater contrast between the potential vegetative and frostless seasons.

WEATHER CONTROL OF THE PERIODICAL CICADA.

By WILLIS E. HURD.

[Dated: Weather Bureau, Washington, D. C., Mar. 29, 1919.]

Mr. Dixon Merritt characterizes the periodical cicada, more popularly known as the 13-year or the 17-year locust, as "the most interesting insect in the world."[1] This interest must lie in the fact of its peculiar life history, particularly its long period of hibernation at a depth of 6 to 24 inches, or sometimes more, under the surface of the ground, and also more or less in its somewhat thrilling musical habits during the few days allowed it in which to dwell amongst the haunts of men.

Comparatively little data have been collected concerning the weather control of this insect, but sufficient information is at hand to permit of some generalizations as well as theories on the subject. The 17-year cicada is largely an inhabitant of the northern States, while its 13-year relative is quite as exclusively confined to the South. Since these insects are physically identical, except in one or two minute particulars, it was very reasonably suggested that the southern type probably emerges from the nymph state four years the earlier only because of the more favoring climate, since the warmer the weather in general the more is the development of the individual facilitated. However, there are no intermediate zones of development graduating from one of a 13-year period along the southern borders of the Gulf States, to another of a 17-year period along the Canadian border, and the two brood types do not change the length of their hibernation periods, except for slight individual and local diversions, even in the median regions where they overlap. As early as 1881 and 1885 Prof. Riley made experiments[2] with the two varieties to determine whether each, if transplanted from the outer extreme of its own to that of the other's habitat, would change its date of emergence to conform to that of the other under the widely differing climatic influences. When the times of emergence arrived, trained observers kept watch of the areas where the little colonies had been transplanted, but unfortunately they obtained no positive results upon which to base definite conclusions. So far as weather or climatic control of the cicada is concerned, however, the following concrete rules may be accepted:

With climatic conditions normal, broods will appear according to scheduled time.

With climatic conditions abnormally warm or cold during the period of hibernation the broods may appear a few days earlier or later than the scheduled time.

In addition, cool weather intervening while the broods are emerging will cause a delay in the appearance of those not already arrived.[3]

The southernmost members of a brood will sometimes appear from a few days to three or four weeks in advance of the northernmost, depending upon temperature conditions.

Some interesting instances of accelerated emergence have been observed. At Belvidere, Ill.,[4] an old apple orchard, in which a swarm of cicadas had lived in 1888, was grubbed up a few years later and the ground covered

[1] The "17-Year Locust" in 1919. U. S. Dept. of Agr. Circ. 127, p. 3.

[2] The Periodical Cicada. C. L. Marlatt. Bur. of Ent. Bul. No. 71, pp. 18-20, 1907.
[3] Ibid., p. 90.
[4] Ibid., p. 24.

with greenhouses. This area was thus artificially warmed and protected, and the hibernating insects indwelling due to emerge in 1905, appeared a year earlier in quantities in the greenhouses. At Alton, Ill.,[5] a certain soil area was equipped with underground flues for forcing vegetables, and the heat caused the cicadas within range of its influence to appear in March instead of in May.

Frost may play an important part in the control of this insect. The story of a 13-year swarm known as brood 19, which appeared in Tennessee in 1894, is an interesting one, and the concluding chapter is expected to be read in 1920. Light frosts occurred in the eastern and central portions of the State on May 29, 1894, while the cicadas were coming forth, and large numbers of the tender arrivals perished from cold without laying eggs. Singularly enough, upon the reappearance of the brood in 1907, on the 28th of May, frosts were even more widespread than in the preceding instance, and such numbers of the insects were destroyed that very few if any of their descendants may remain to greet the interested observers from the Department of Agriculture who will watch for them next year.

There are many cicada broods in various stages of development under the soil of the United States, and the largest of the 17-year broods is preparing to appear over a considerable territory east of the Mississippi River this spring. The nymphs are already lying near the surface in and about the District of Columbia, awaiting the time to crawl forth into the daylight and scramble for trees and bushes in which to shed their pupal skins. The usual time of appearance is during the last week or ten days of May, but some entomologists are wondering if they may not arrive a few days earlier than usual this spring, owing to the extraordinarily open winter. Still, it is also suggested, and that by one of our meteorologists, that the probable more rapid development of the insects this year may go only toward offsetting the as probable retardation due to the cold of the preceding winter.

[5] Ibid., p. 90.

BIBLIOGRAPHY.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Professor in Charge of Library.

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

Aldrich, L[oyal] B[laine].
The reflecting power of clouds. Washington. 1919. p. 1., 9 p. chart, tables. 24½ cm. Smithsonian miscellaneous collections. Volume 69, no. 10. (Publication 2530.) [Abstract in March, 1919, REVIEW.]
The Smithsonian eclipse expedition of June 8, 1918. Washington. 1919. 17 p. plates. charts. tables. 25 cm. [Cf. pp. 5–16 in January, 1919, REVIEW.]

Alfani, Guido.
Note ed osservazioni sui terremoti della regione littoranea adriatica nell'agosto del 1916. Firenze. 1916. 47 p. maps. tables. 24 cm. Pubblicazioni dell'Osservatorio Ximeniano dei PP. Scolopi, Num. 122.

Alt, Eugen.
Meteorologie für Flieger. Berlin. 1917. viii, 116 p. plates. charts (part. fold.) tables. diagrs. 15½ cm.

Australia. Commonwealth bureau of meteorology.
Results of rainfall observations made in South Australia and the Northern Territory, including all available annual rainfall totals from 829 stations for all years of record up to 1917, with maps and diagrams; also, appendices, presenting monthly and yearly meteorological elements for Adelaide and Darwin . . . Melbourne. 1918. 421 p. fold. map. charts. tables. 31½ cm.

Chile. Instituto meteorológico y geofísico.
Anuario meteorologico de Chile, 1914–1916. Santiago de Chile. 1916–1918. 4 v. plates. tables. 27–37 cm. 1915 in 2 parts. Part 1 in Spanish and German. Publicaciones Nos. 19, 22, 25, 26.
Lluvias en 1916–1917. Santiago de Chile. 1917–1918. 2 v. tables. fold. diagrs. 26½ cm. Seccion lluvias. Publicacion Nos. 23, 24.

Coit, J[ohn] Eliot.
Citrus fruits; an account of the citrus fruit industry with special reference to California requirements and practices and similar conditions. New York, 1917. xx p., l., 520 p. front. illus. chart. tables. 19½ cm. Bibliography, p. 461–503. [Chapter 2.—Citrus geography and climatology of California. Chapter 14.—Frost and orchard heating.]

Day, Walcott.
Influence of the ocean on Atlantic City's climate. (Excerpted from Atlantic City, Official publication of the Atlantic City Chamber of commerce. Feb. 1919. No. 48. p. 12.) 28½ cm.

Denmark. Meteorologiske institut.
Meteorologisk aarbog . . . Annuaire météorologique. 2me partie, 1916; 1ère partie, 1917. Kjøbenhavn. 1918. 2 v. tables. 31 cm.

Ekelöf, Gösta.
Studier over Gavleåns hydrografi och samband med vattenområdets ekonomiska geografi. Stockholm. 1918. 2 p. l., 124 p. illus. fold. maps. charts. tables. 31½ cm. At head of title: Meddelanden från Hydrografiska byrån, 9. Källor och litteratur, p. 99–101. Résumé in French, p. 103–106.

Eredia, Flipppo.
Il clima di Gorizia nel quarantacinquennio 1870–1914. Torino. 1919. 11 p. 8 tables. 27½ cm. (Estratto dal "Bollettino bimensuale" della Società meteorologica italiana. Anno 1917–N. 6–9.)

France. Service météorologique aux armées.
Organisation & fonctionnement des sections de sondages par le son. Paris. 1918. 78 p. illus. plates. diagrs. (part. fold.) charts. map. 27½ cm. At head of title: Service géographique de l' armée. [A new aerological process for observing the movement of air currents by means of pilot-balloons equipped with audible signals. See p. 70 of this REVIEW.]

Georgetown University. Seismographic station.
The registration of earthquakes and press dispatches on earthquakes from January 1, 1918, to January 1, 1919, by F. A. Tondorf. Washington. [1919] 31 p. tables. 23 cm. Bulletin of the Seismographic station no. 3. (Georgetown University publ. Fifteenth series. No. 2.)

Gockel, A[lbert].
Beitrage zur Kenntnis von Farbe und Polarisation des Himmelslichtes. tables. 22½ cm. (Sonderdruck aus Annalen der Physik, 4 Folge, Bd. 56, 1918. p. [617]–638.)

Great Britain. Civil aerial transport committee.
Reports of the Civil aerial transport committee with appendices. London. 1918. 33 p. 33½ cm. [Issued by Air ministry. Meteorology, p. 46, 50–51, 58, 78–79. Reviewed in this issue of the Mo. Wea. Rev. p. 80.]

Great Britain. Meteorological office.
Instructions for the use of lightning recorders. [London. 1916.] 3. p. plate. diagrs. 24 cm. The observers' handbook, Supplement. M. O. 191a.
The observer's handbook . . . Annual edition, 1918. London. 1918. xxviii, 139 p. plates. illus. tables (part. fold.) 25 cm. M. O. 191 (1918).
Syllabus of weather study for elementary schools. London. n. d. 4 typewritten sheets. 33 cm. Cir. E. 01.

Great Britain. Naval meteorological service.
Naval meteorological service cloud atlas. Prepared by Hydrographic department, Admiralty, under the superintendence of Rear Admiral J. F. Parry. [London] 1918. p. 1, 14 col. plates. 48½ x 39 cm. [Large colored prints of oil paintings by G. A. Clarke.]

Guidi, Pietro.
I terremoti lucchese (anni 1112–1915.) Lucca. 1915. 58 p. 24½ cm. At head of title: Pubblicazioni dell' Osservatorio Ximeniano dei PP. Scolopi, Firenze. Num. 120.